Workshop 3:
Model-based Systems Engineering applied in Concurrent Engineering

ISU – Space Studies Program 2013

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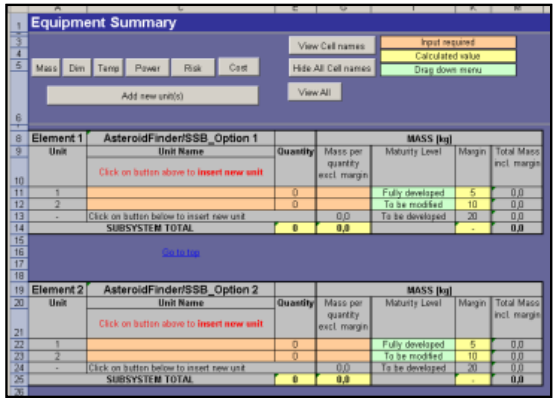
Concurrent Engineering

You will learn:

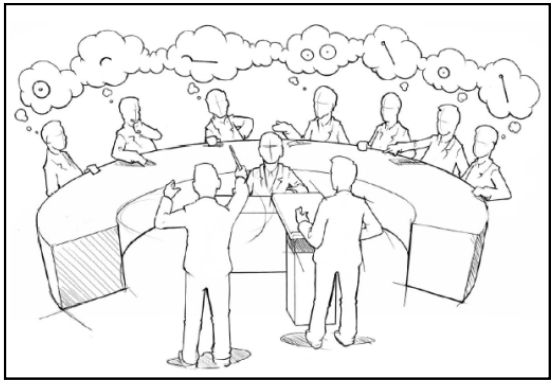
- **What is Concurrent Engineering (CE)?**
  - Definition & characteristics
  - What are the different elements?
- **What are typical preparations?**
  - Which phases do exist?
  - Teaming & starting point
- **How can CE activities be performed?**
  - Who does it how in which entity?
  - What are the results and products?
- **What is important for *successful* CE?**
  - Technical & social considerations
  - Mandatory things to be aware of

Source: DLR DWS

Source: ESA IDM

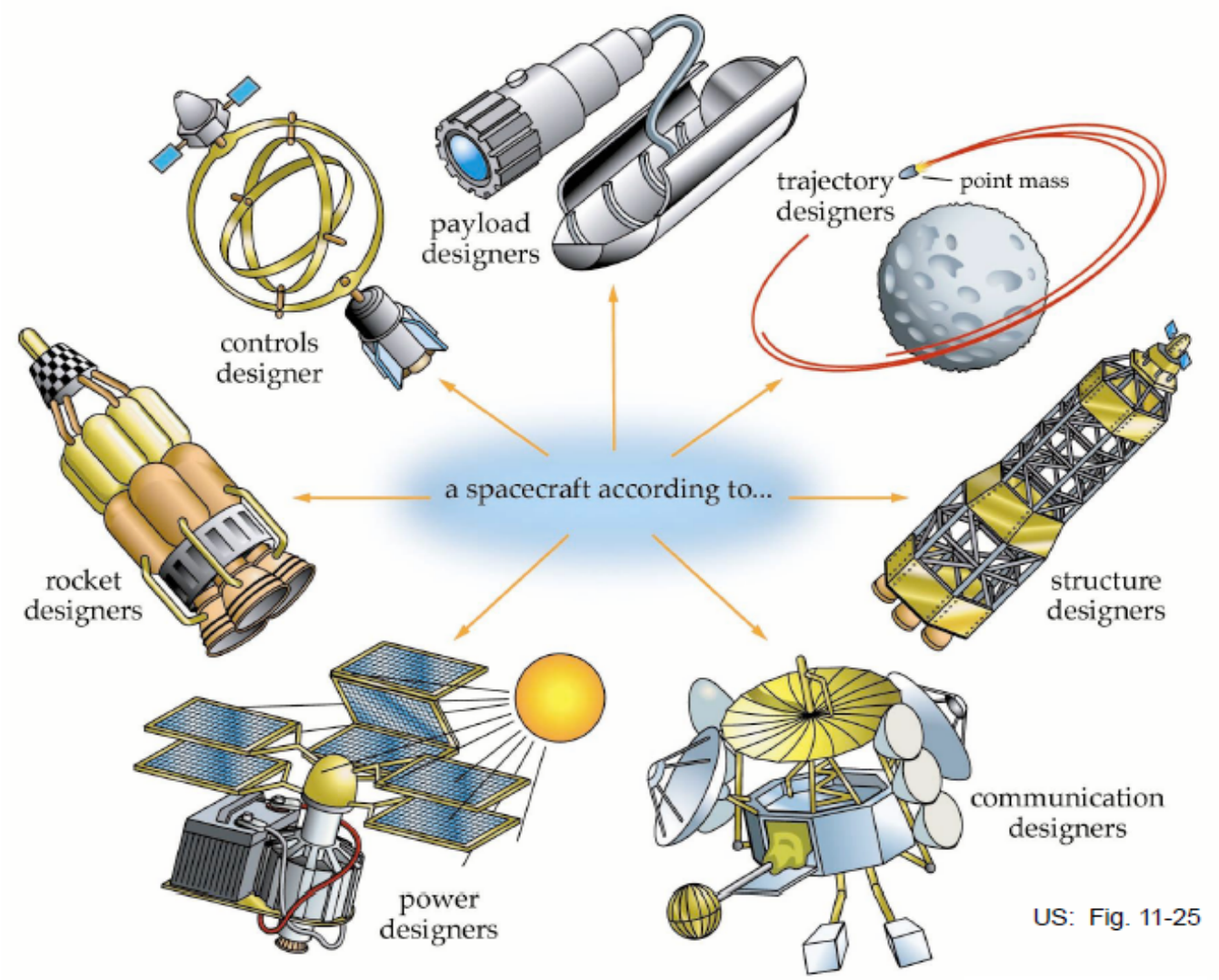


Source: (J-CDS)



* Details in MBSE part *

Systems Engineering?



Source: e.g. TSTI

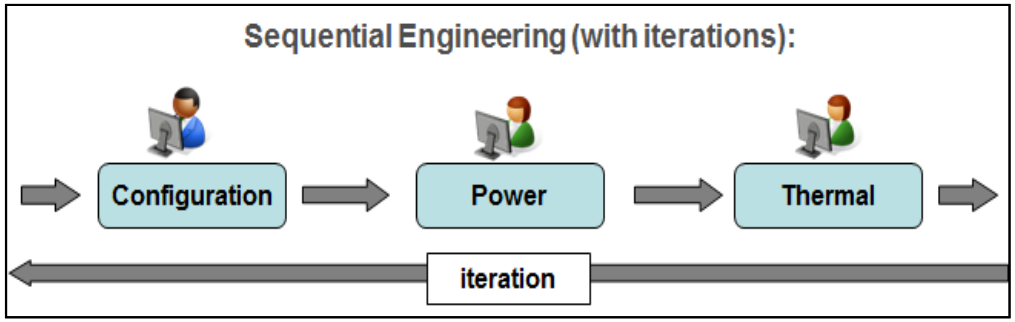
Concurrent Engineering - Definition

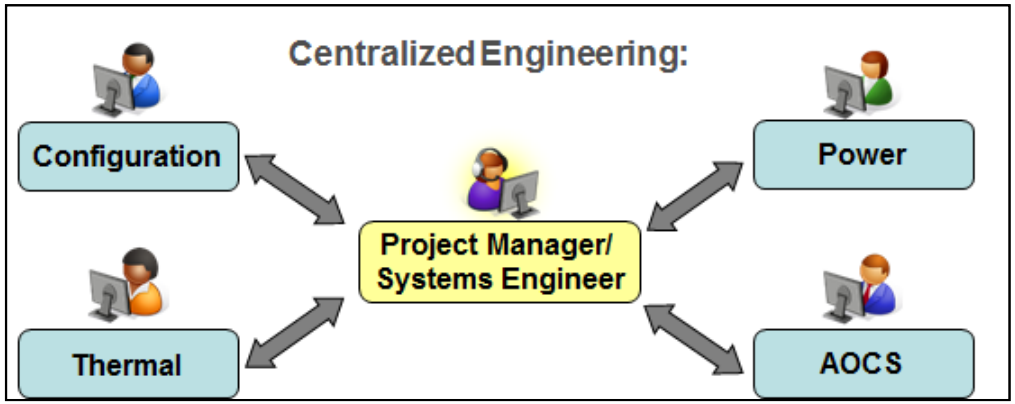
- **ESA's preferred definition:**

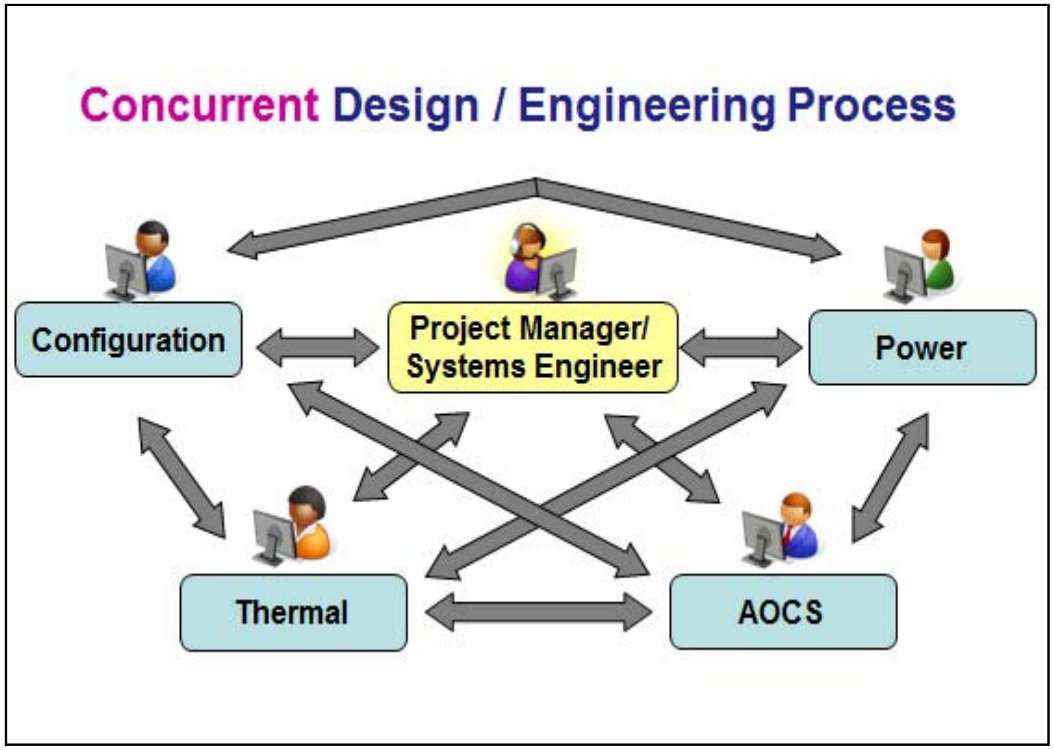
  "Concurrent Engineering is a systematic approach to integrated product development that emphasizes the response to customer expectations. It embodies team values of co-operation, trust and sharing in such manner that decision making is by consensus, involving all perspectives in parallel, from the beginning of the product life-cycle."

Concurrent Engineering - Differences

Sources: Adapted from ESA, 2010





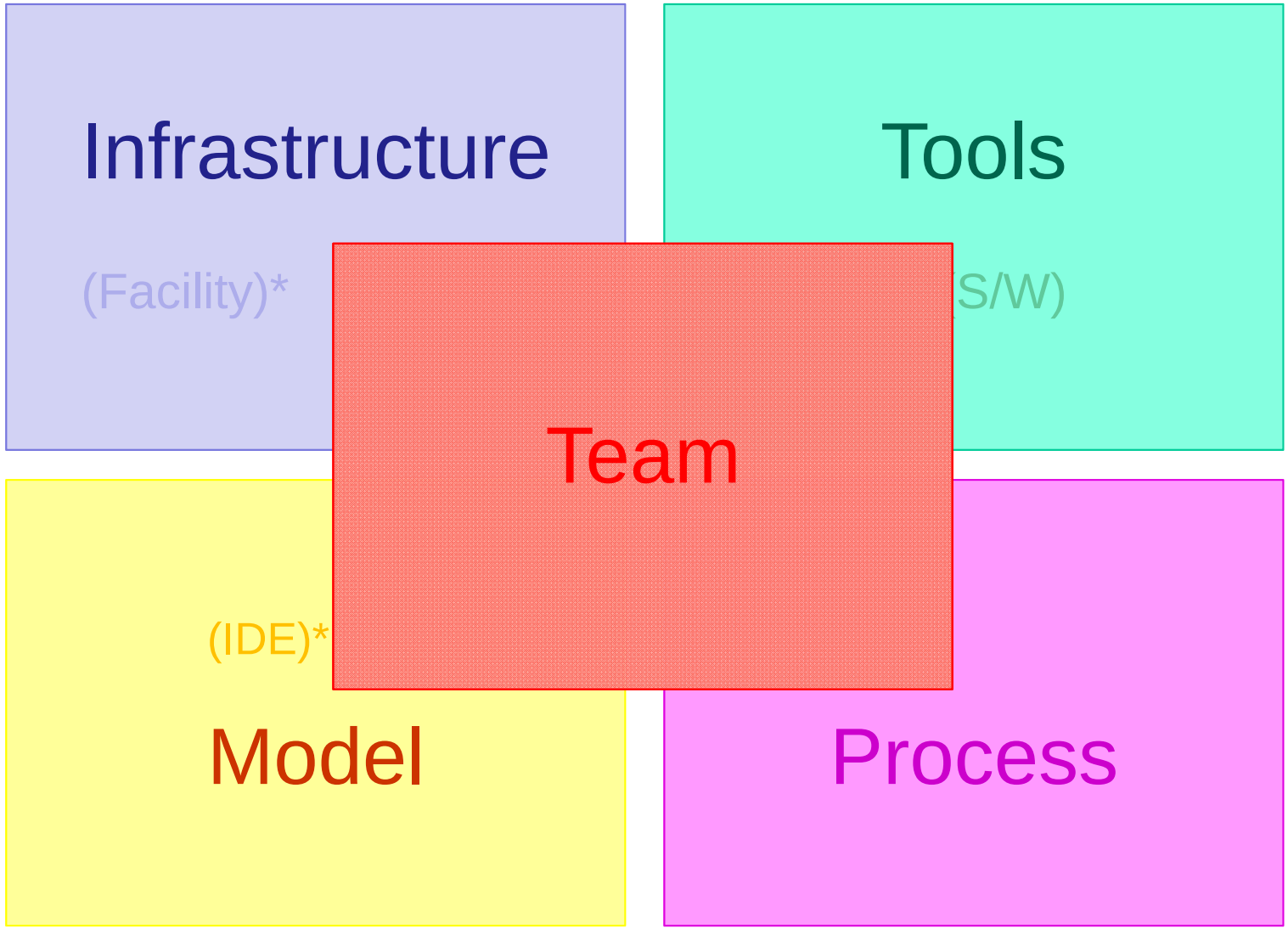


Classical (space) engineering 'views'

Concurrent engineering perspective

*Terms used at ISU, e.g.:
IDE = Integrated Design Environment

Concurrent Engineering - Elements



Source: Adapted from Wilke, 2002

MBSE = Model-based Systems Engineering

Element #1: Infrastructure

ISU Concurrent Design Facility

ESA Concurrent Design Facility

DLR Concurrent Engineering Facility

NASA JPL Team-X

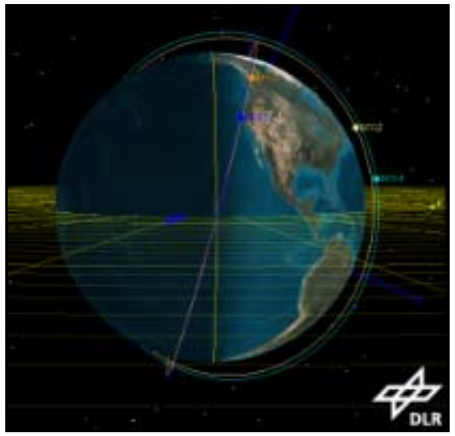
- **Why?**
  - 'Old school' → We have MBSE, no?!
  - *but*: more communication paths
  - *and*: much less IT-issues

- **An infrastructure is not mandatory, but very (!) nice to have…**
  - Tele- and videoconference systems allow external participation
  - *but*: co-location, i.e. sitting together, beats distributed engineering

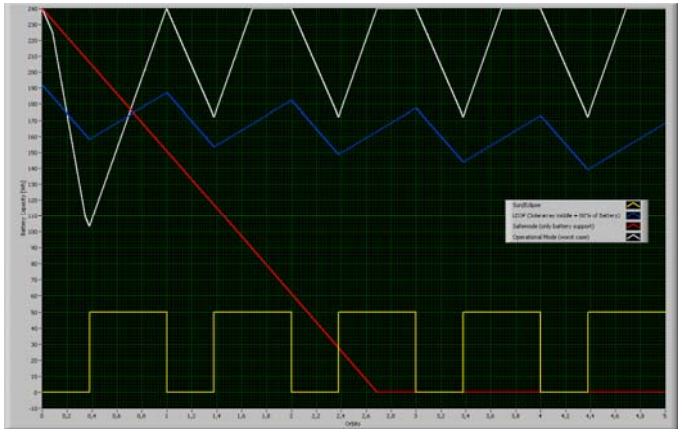
Element #2: (Domain specific) Tools

- **Purpose:** Support domain specific calculations & simulations
- **Examples:** CATIA, Satellite Toolkit (STK), Matlab, Excel-tools
- **Required:** Rapid analysis, sufficient level of detail, user-friendly
- **Desired:** Linked with common data model

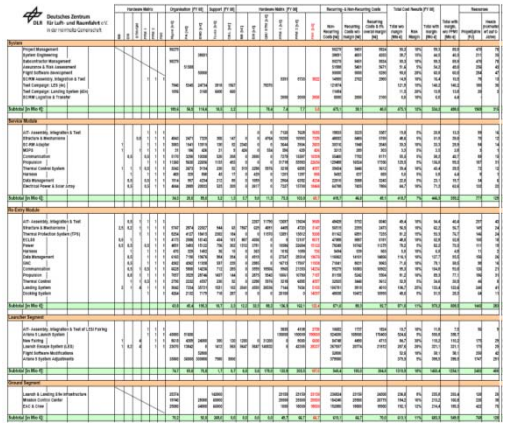
STK



Matlab / Simulink



Cost Model

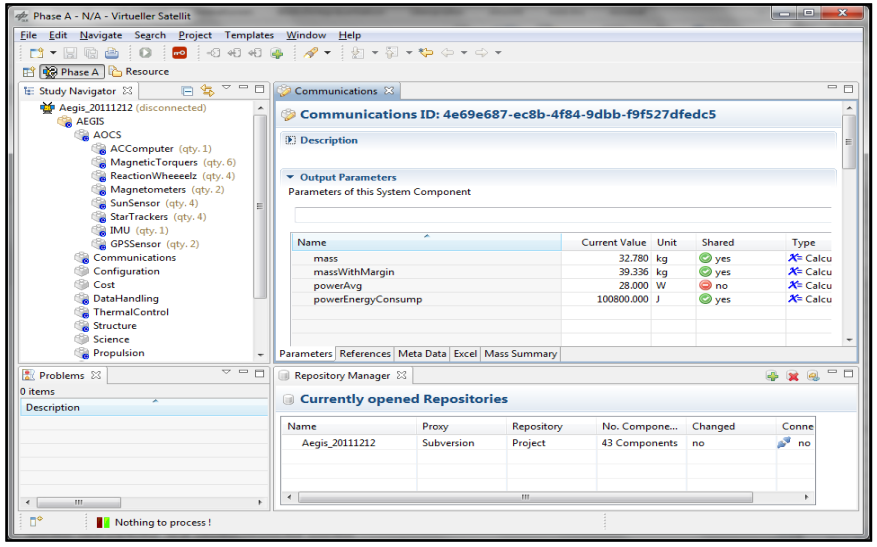


***IDM = Integrated Design Model**
OCDT = Open Concurrent Design Tool
CDP = Concurrent Design Platform

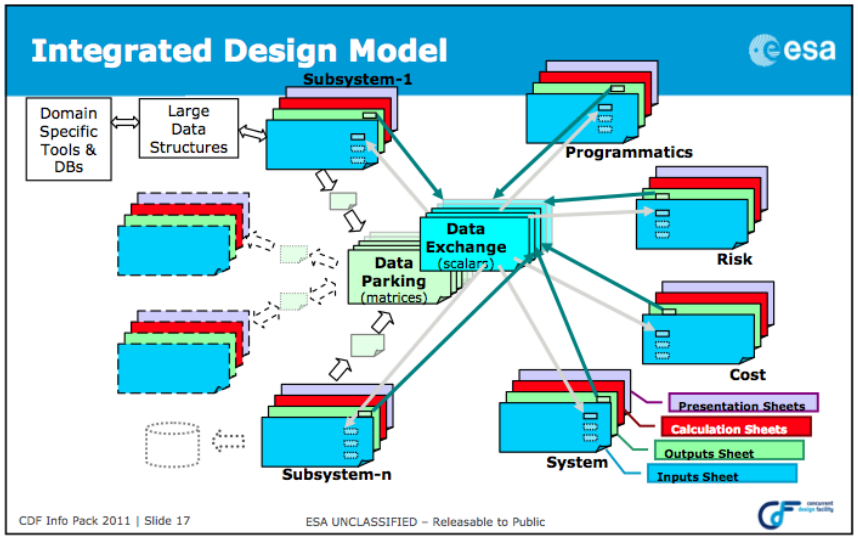
Element #3: Model

- **Purpose:** To provide, share and use data in a central pool
- **Examples*:** ESA IDM, ESA OCDT, CDP, (v)SysEd, DLR VirSat
- **Required:** Multiple simultaneous access, rights- & parameter mgmt.
- **Desired:** Linked with domain specific tools (DST)

DLR Virtual Satellite (VirSat)



ESA IDM (Excel-based exchange + DST)

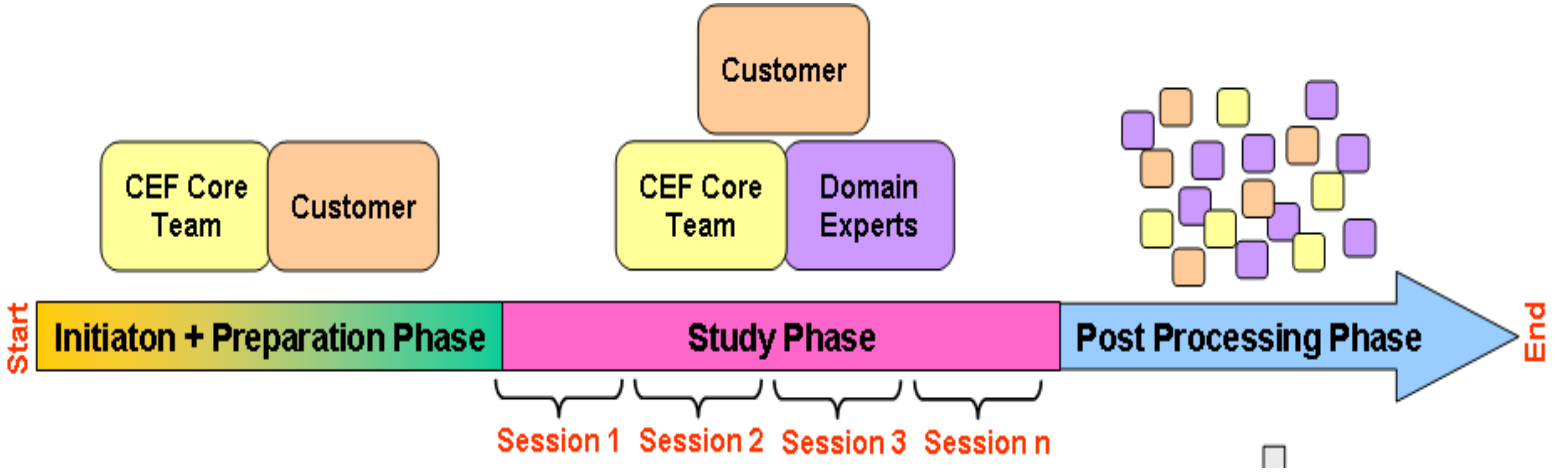


Element #4: Iterative & Formalized Process

- **The four typical phases**
  1) Initiation
  2) Preparation
  3) **Study,** e.g. 5days →
  4) Post-processing

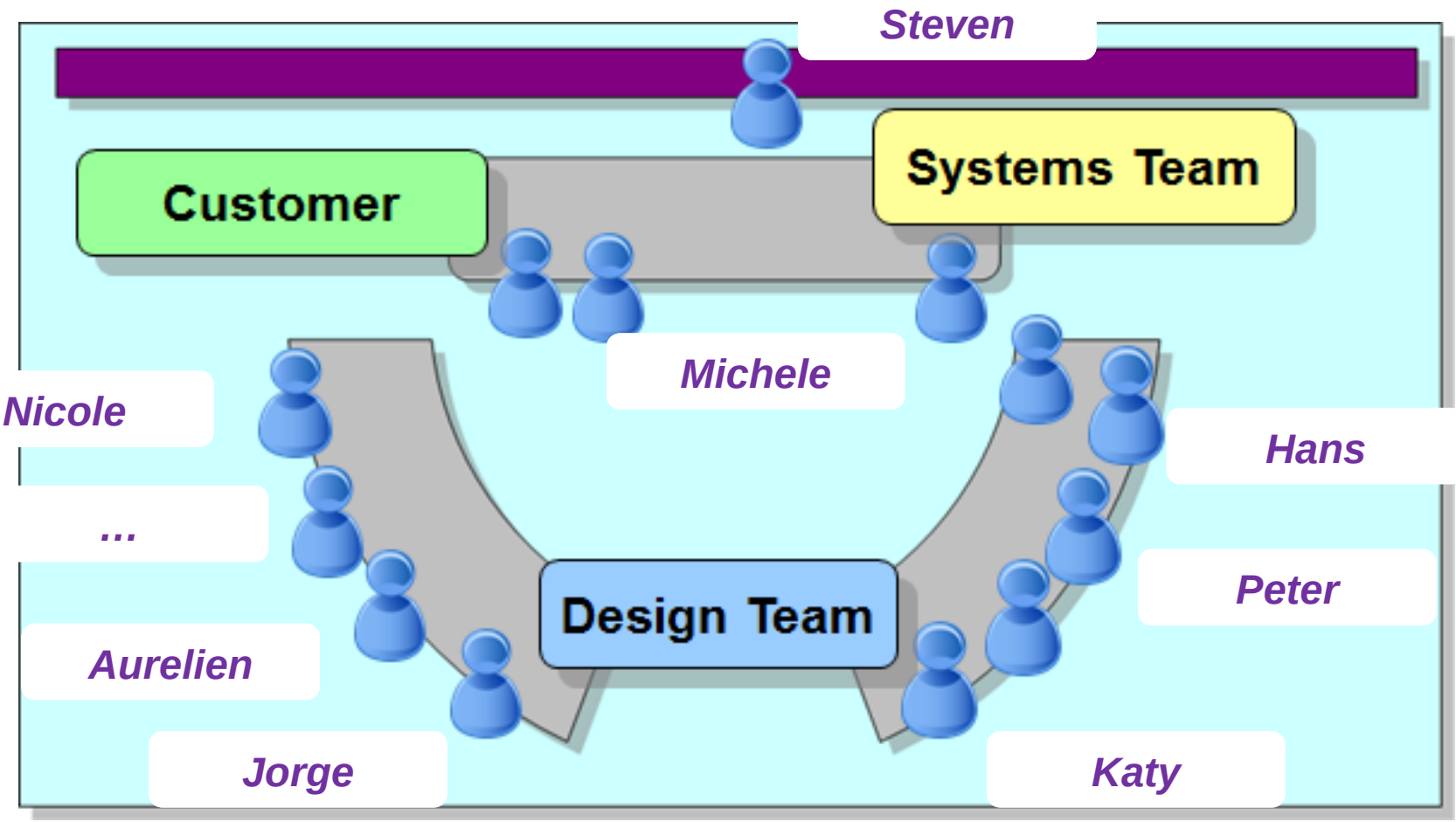
DLR-CEF Study Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
morning	*Team Arrival* / Kick-off Presentations	*"Offline"-processing*	Plenary CE-Session #2	Plenary CE-Session #3	Plenary CE-Session #4
	Lunch / Break				
afternoon	Plenary CE-Session #1	*"Offline"-processing*	*"Offline"-processing*	*"Offline"-processing*	Final Presentations / *Team Departure*



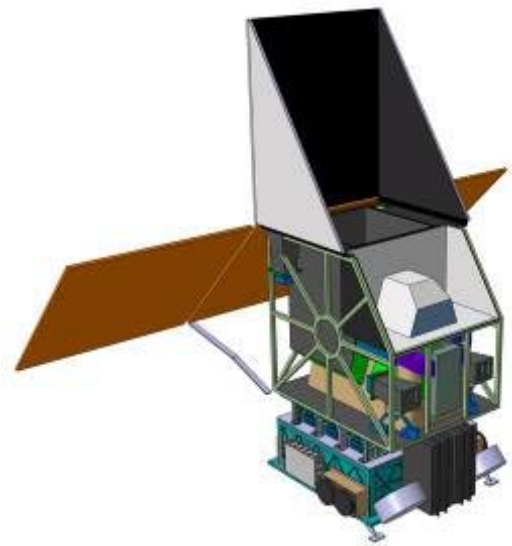
MOST important part

Element #5: An interdisciplinary Team (1/2)



MOST important part

Element #5: An interdisciplinary Team (2/2)



Customer *(e.g. scientists, project lead)*

- Payload(s)
- Structure / Mech.
- Propulsion
- Attitude Control
- Power
- Thermal
- Telecomms.
- Data Handling

+

- Configuration
- Mission
- Operations
- Cost
- Risk
- Radiation
- Space Debris

Team Leader, Systems Engineer

Required Study Phase Preparations

ISU CDF requires here:
Space Mission Design

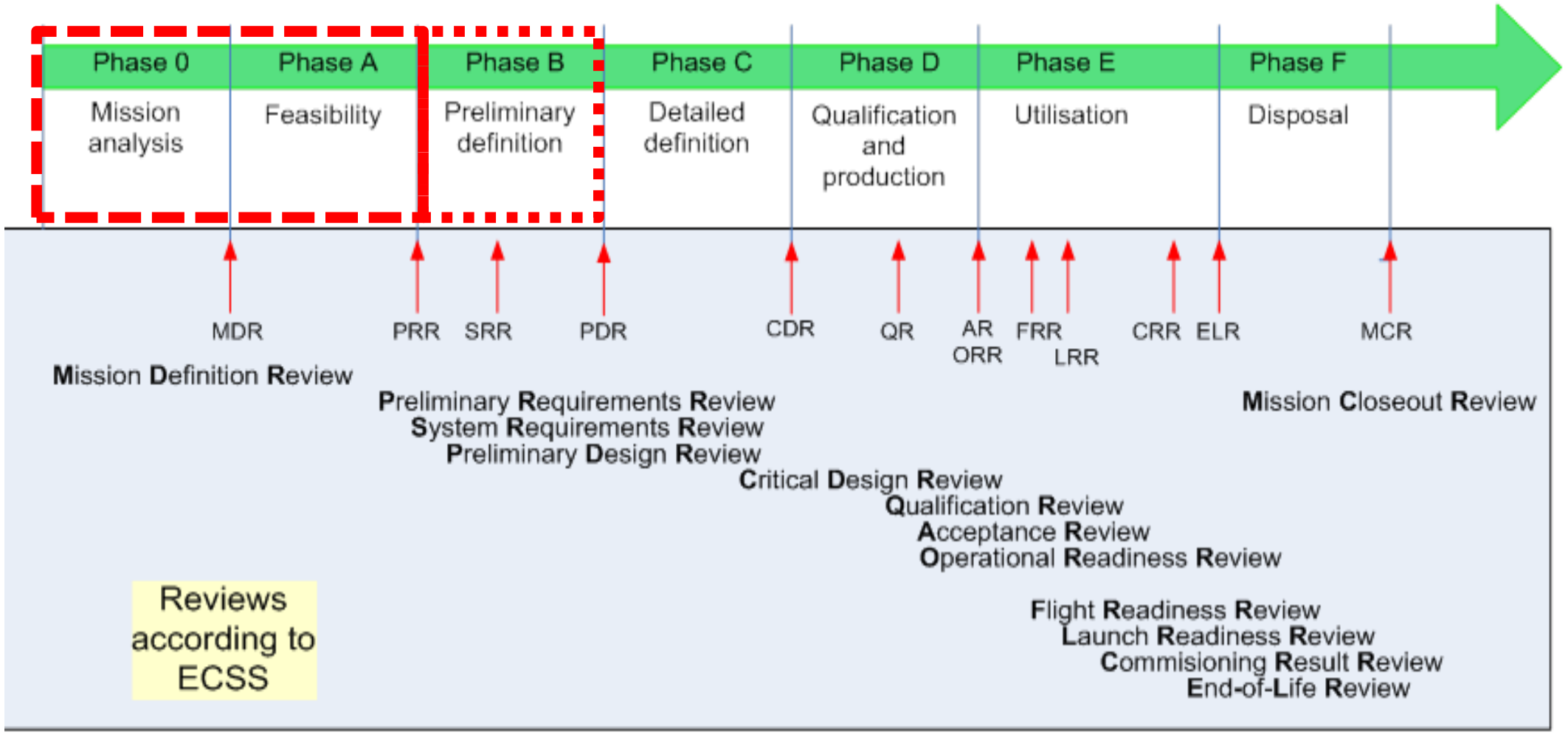
- **Technically**
  - Study objectives
  - Mission objectives
  - Initial requirements
  - Mission analysis
  - (Pre-)configuration
  - Data model
  - Data references
  - Hard-/Software*

- **Socially**
  - Disciplines (What?)
  - Team set-up (Who?)
  - Availability + backups
  - Clear overall schedule
  - Breaks after iterations
  - Arrival & departure
  - Social event(s)
  - Access to infrastructure

***especially, if external people use external tools or licences**

ECSS = European Coorperation for Space Standardization

Application of Concurrent Engineering (today)



TAS = Thales Alenia Space
TUM = Munich Technical University
ASI = Italian Space Agency
CNES = French Space Agency
EPFL = Federal Tech. Inst. Lausanne
JAXA = Japanese Aerosp. Expl. Agency
SAS = Satellite Systems

Who does it how?

- **Just a few examples:** *(don't worry about the acronyms…)*

		Study Duration	Session / week	Design Team
PDC	NASA Team-X	~3 days	3	constant
IDC	NASA GSFC	~1 week	4-5	constant
CDF	ESA	~ 2-3 months	1-2	variable
CEF	DLR	1-3 weeks	4-5	variable
CDF	ISU	1 week (in M.Sc.)	~4	variable/students
	Astrium SAS	days-weeks	tbc	variable
& CNES*, ASI*, TAS*, TUM*, La Sapienza (Rome), EPFL*, JAXA*,…				

SpaceCode CIC CEF CDF CDF MDC

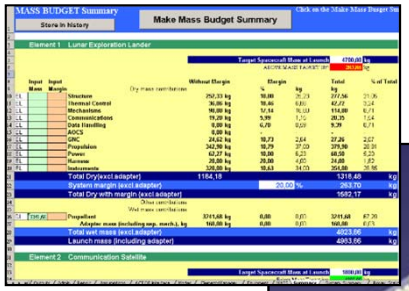
The “CE elevator pitch”

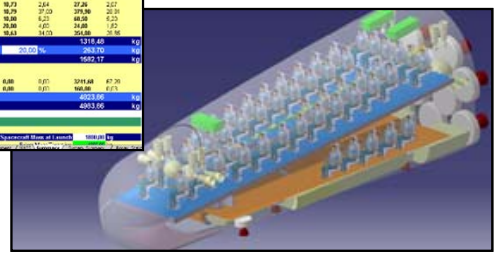
Source: vocabase.com

- **CE is**
  - a systematic (& guided) process,
  - parallel and iterative work,
  - with clear responsibility share and is
  - very suitable for early project phases

- **This approach**
  - *increases:* consistency, quality
  - *reduces*: cost, time, mistakes

- **CE(-study) products are e.g.:**
  - Mission & spacecraft (3D-)design
  - Consistent parameter set, incl.:
    - budgets (technical & cost)
    - product tree
  - Data references & documentation

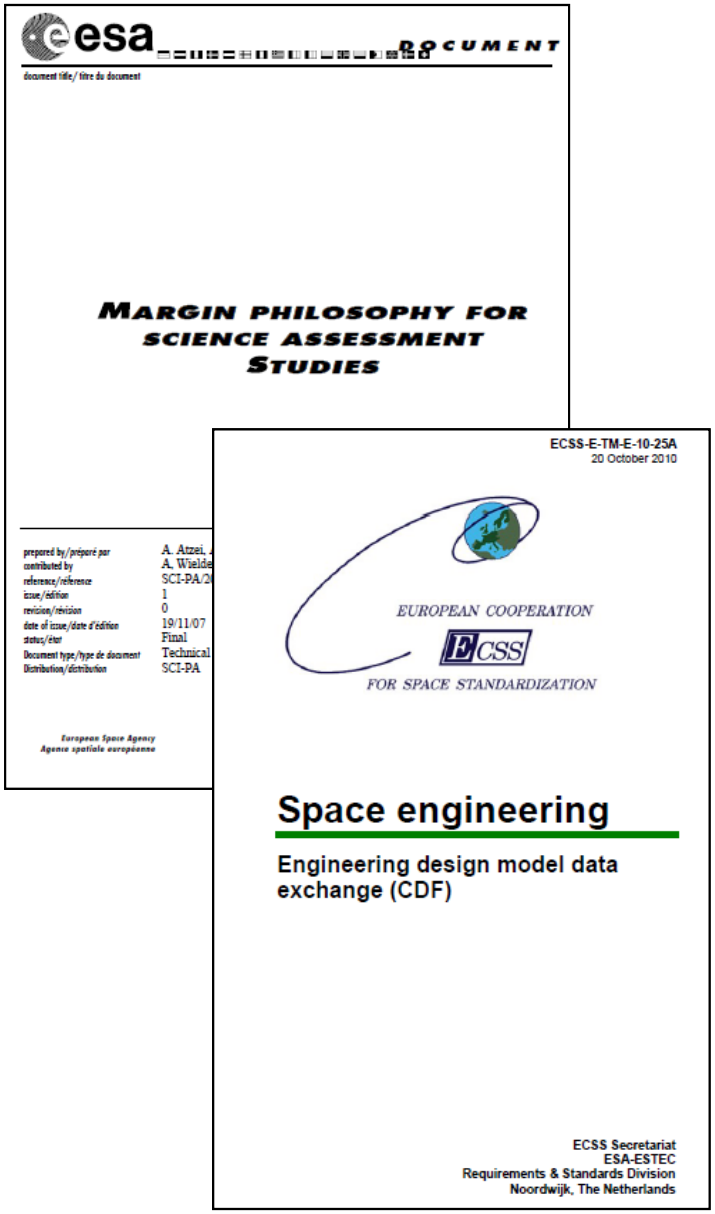




ECSS = European Coorperation for Space Standardization

Important things to remember

- **As for any project**
  - Clear work share & responsibility
  - Define margin philosophy
  - Communication is *the key*
    - within team & to customer
- **Concurrent Engineering / Design**
  - Clear objectives → Do not waste time
  - Be aware of engineers way of working
  - Provide initial assumptions → iterate
  - Work in *on-line* & *off-line* sessions
- **Important Standards (**in Europe**)**
  - ECSS-E-TM-10-25A → data exchange
  - ISO/IEC 80000 → quantity & units
  - ESA margin philosophy guidelines



Questions so far

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